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Field Observations of Variability of Soil Gas Measurements

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FIELD OBSERVATIONS OF VARIABILITY OF SOIL GAS MEASUREMENTS

1.0 INTRODUCTION

A baseline monitoring survey is being performed at the U. S. Department of Energy's Hanford Site located in southeast Washington State. Monitoring is in support of the carbon tetrachloride Expedited Response Action (ERA) vapor extraction system (VES) operations. Since late 1991, soil-gas probes and wellheads have been routinely monitored for volatile organic concentrations. The monitoring network now encompasses 59 locations. These include 46 wellhead locations, 11 shallow soil-gas probes [1.2 m (4 ft) deep], and 2 deep soil-gas probes [11 and 22 m (37 and 73 ft) deep].

The project site is an area where carbon tetrachloride (CCl_4) and co-contaminants were discharged to the soil between 1955 and 1973. There are three separate CCl_4 disposal areas at the project site. This contamination is linked to past liquid waste disposal practices resulting from operation of the Plutonium Finishing Plant at the Hanford Site. The contamination caused an extensive vapor plume in the vadose zone and a groundwater contamination plume that covers over 12 km^2.

The following are the objectives of this baseline monitoring survey: 1) to measure the existing concentrations of CCl_4 in the subsurface prior to initiation of the vacuum extraction; 2) to investigate how the existing concentrations of CCl_4 vary with time; 3) to evaluate the impact of vapor extraction on the distribution and concentrations of CCl_4 in the subsurface; and 4) to provide data to help maintain a safe working environment.

2.0 METHODS

Baseline monitoring is performed at the Environmental Protection Agency analytical level I. Field screening is conducted using an Organic Vapor Monitor (OVM) outfitted with an 11.8 eV lamp. Discrete samples are collected twice a week and the data is entered on a data sheet and logged internally within the instrument for later retrieval. One round of sampling usually takes less than four hours to complete.

All monitoring instruments are calibrated daily. Isobutylene calibration standards are certified and traceable to a national or industry recognized standard. For consistency in monitoring with the OVM, the response factor was set at 1.0.

To begin the sampling routine, the sampler monitors around the edge of the well cap, then lifts the well cap and inserts the OVM probe into the well. The sampler then draws air through the instrument while monitoring the real time readings; this continues while the readings increase. Once the reading has reached a maximum peak, the maximum value is recorded on a data sheet and internally within the instrument. At each station, air is drawn through the instrument for at least ten seconds.

If the sample reading is not reproducible or sample readings vary for no apparent reason, the instrument is challenged with calibration gas. If the challenge is not within 10% of the original calibration, the instrument is recalibrated. At the end of each day's sampling the instrument is challenged with a calibration standard.

3.0 RESULTS

Results of the monitoring indicate concentrations of volatile organic compounds (VOC) vary widely over time and space. Previous analysis with a gas chromatograph indicates that the majority of VOCs present in the wellheads and soil-gas probes is CCl_4. During the course of the monitoring, sample readings with an OVM reached a wellhead high of 10,704 ppm, a shallow soil-gas probe high of 97.4 ppm, and a deep soil-gas probe high of 10,400 ppm. The assumption is that the VOCs measured with the OVM are CCl_4.

3.1 SHALLOW SOIL-GAS PROBE DATA

The shallow probe data is fairly consistent and uniformly lower than the wellhead data. Of the 11 stations routinely monitored, the highest average VOC value was 7.3 ppm. The lowest average value was 1.5 ppm. The maximum probe value detected was 97.4 ppm. Results from shallow soil-gas probes show less variability than data from well head measurements. This is caused primarily to the construction and installation method used. The shallow soil-gas probes were installed in a uniform method, to a uniform depth of 1.2 m (4 ft). The probes range in distance from 1 to 58 m (3 to 190 ft) to a CCl_4 disposal site.

3.2 DEEP SOIL-GAS PROBE DATA

Two deep soil-gas probes were emplaced at the 216-Z-9 Trench area. The deepest probe [22 m (73 ft)] consistently yielded high organic vapor measurements. Results ranged from 0 to 10,400 ppm of VOCs; the average value was 769.5 ppm.

The other deep probe [12 m (40 ft)] station was emplaced in August 1992. The limited data set has lower values (0 to 30.6 ppm), with an average value of 7.8 ppm.

4.0 WELLHEAD SAMPLING DATA

The 46 wells routinely monitored now were installed over a 38 year period (1954 to 1992) using different drilling and completion methods. Depths range from 23 to 182 m (76 to 600 ft) below surface. Screen lengths vary and screened intervals lithologies include sands, gravels, cobbles, boulders, and clay. Depth to groundwater ranges from 58 to 65 m (190 to 214 ft). The wells are located at distances from 0 to 90 m (0 to 296 ft) from CCl_4 disposal sites.

Because of the differences of well construction, location, and sampling times, wellhead concentrations varied widely. The VOCs measured with an OVM had a high of 10,704 ppm. While the data itself is valid, comparisons between different wellheads are difficult.

5.0 IMPACT OF VAPOR EXTRACTION ON SOIL-GAS CONCENTRATIONS

The VOCs in shallow soil-gas probes emplaced near the ERA site may be influenced by the VES operation. Throughout spring and early summer, shallow soil-gas probe concentrations varied from barometric pressure and other natural factors. On July 10, 1992, vapor extraction with a granular activated carbon removal system began from two wells and on July 23, 1992, two additional wells (a total of four wells) were added to the VES. This continued until September 23, 1992, when extraction was reduced to only three wells.

The data indicates a significant decrease in detectable volatile organics in shallow soil-gas probes up to 35 m (115 ft) west and southwest of the ERA site. Four probes show very low or no detections through the end of the reporting period (July 20 to September 30, 1992).

While other factors may contribute to the very low detections, there is enough evidence to suggest operation of the VES may influence the shallow soil-gas probe concentrations.

6.0 IMPACT OF VAPOR EXTRACTION ON WELLHEAD CONCENTRATIONS

A comparison of the wellhead VOC concentrations and the VES extraction schedule indicate no similarities. While the VES may influence wellhead concentrations, currently there is no evidence in the baseline monitoring data to support this.

7.0 NATURAL FACTORS AFFECTING DETECTIONS OF VOLATILES

7.1 BAROMETRIC PRESSURE

Barometric pressure appears to be the dominant natural factor affecting baseline monitoring data. There is evidence in the data to confirm this correlation. The low pressure and increased wellhead concentrations appear to be fairly consistent. On high pressure days [usually above 74 cm (29.2 in.) of mercury] during May through September, there are rarely any detectable VOCs at wellheads. During December through April, measurements with pressures above 74 cm (29.5 in.) of mercury yielded few detectable volatiles.

The effect of pressure on VOCs in wellheads is usually greatest when there first is a prolonged high pressure period (three or more days), then a sharp drop in pressure. On these days VOC concentrations are usually much higher.

The detection of VOCs in shallow soil-gas probes is not as consistent. Sometimes VOCs are present on low pressure days, and on other occasions also present on high pressure days. This trend of VOC detection in shallow soil-gas probes on high pressure days [above 74 cm (29.2 in.) of mercury] was unexpected. Often these detections on high pressure days would occur during a period of rapidly rising or falling barometric pressure. Often VOCs would not be detectable in wellheads but would be present in shallow soil-gas probes. A possible cause of this occurrence is higher pressure concentrating VOCs normally in the upper meter of soil at a level accessible by the shallow soil-gas probe.

No correlation can be made at this time between VOC levels in deep soil-gas probes and barometric pressure.

7.2 TEMPERATURE

Correlation of temperature effects and baseline monitoring of VOC concentrations is difficult. There may be a relationship between temperature and shallow soil-gas probe VOC concentrations. During December 1991 through early February and late July through September 1992, there were few detections of VOCs in shallow soil-gas probes. Temperature may have been a factor in these low detections.

7.3 PRECIPITATION

A theory exists that precipitation may act as a "cap" to retain VOCs beneath the surface. This theory may be correct, but because most rainfall is associated with low pressure systems, and low pressure does increase detectable volatiles, a direct correlation is difficult to prove. The possibility exists that seasonal variations that cause more rainfall in winter (hence a more moist soil) will cause a general increase in VOC detections during the winter and spring.

7.4 EARTH TIDE POTENTIAL

There appears to be a correlation between earth tide potential and wellhead VOC concentrations. In the winter months (December through mid-March) the low point of maximum tide potential appears significant. During these periods there are frequently detectable VOCs. Because of the seasonal nature of this trend, it is possible there are actually other causes or multiple causes that work to enhance the effect of earth tide potential. If this tidal period coincides with low barometric pressure, the concentration of VOCs is even greater.

8.0 CONCLUSIONS

There is evidence that operation of the VES may cause a decrease in detectable VOCs in shallow soil-gas probes.

There appears to be a correlation between increased VOCs detected in shallow soil-gas probes and high barometric pressure. There is ample evidence to support previous theories that wellhead concentrations of VOCs increase with decreasing barometric pressure.

Wellhead concentrations may be affected by tidal forces. During the winter (December through mid-March), increased wellhead concentrations can be correlated with many lows of the maximum earth tide potential. It is difficult at this point to make this correlation to soil-gas probes, or during any other season. Additional work to clarify the affect of tidal forces is warranted.

Real time VOC emission wellhead sampling is a method useful in helping determine subsurface VOC concentrations and their changes caused by natural factors. Comparison of sampling results from wellhead to wellhead can only be done in gross terms. The different sample collection times, various well depths, screening intervals, and completion methods make strict comparisons dubious.

Comparison of soil-gas probe data and wellhead monitoring data is difficult at best. As discussed earlier, differences in emplacement method and depth make comparisons of questionable significance.

Figure 1. Sample Point SG N-2 Barometric Pressure
December 1991 to April 1992 (inches of mercury).

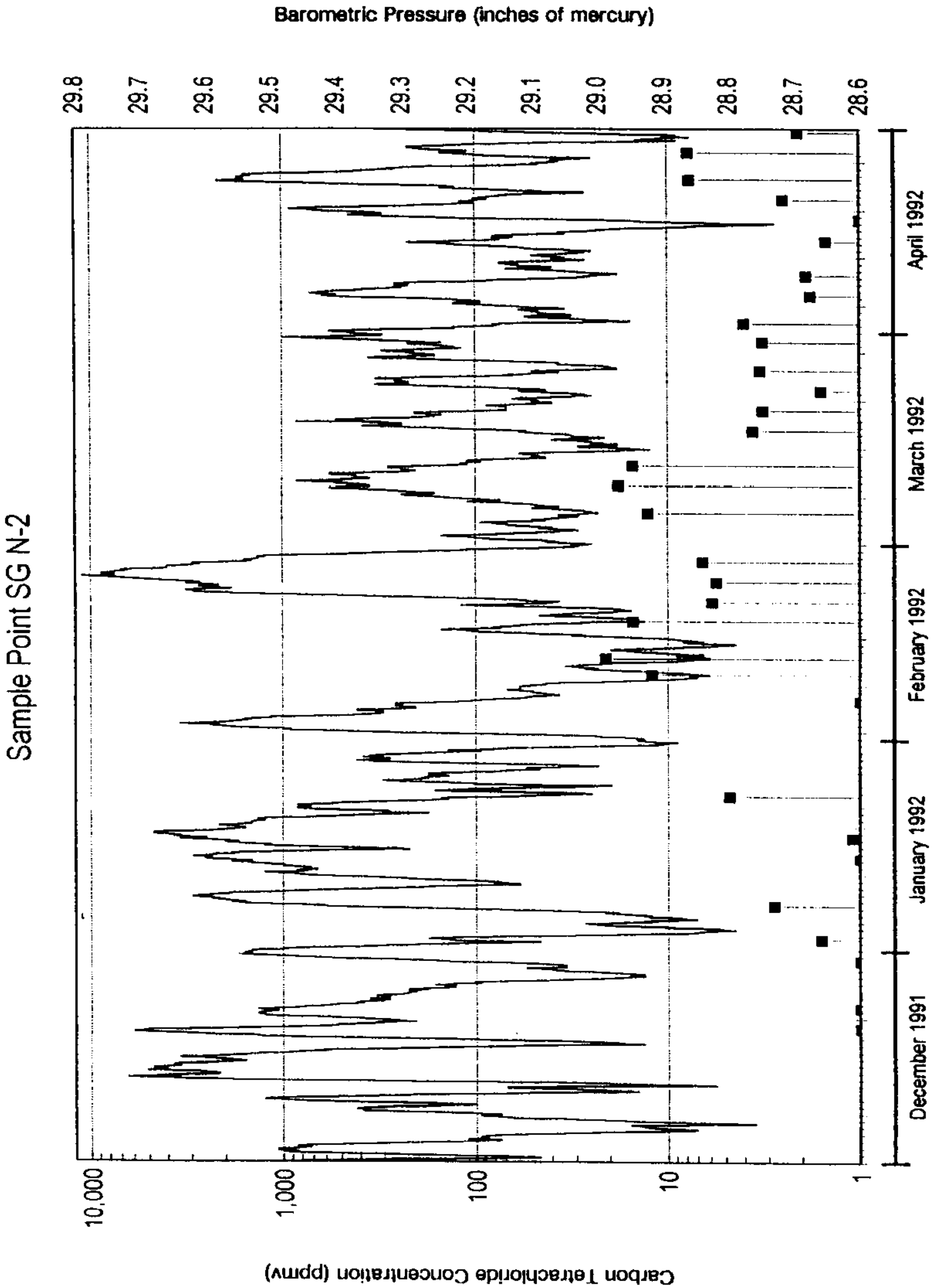


Figure 2. Sample Point SG N-2 Barometric Pressure
May to September 1992 (inches of mercury).

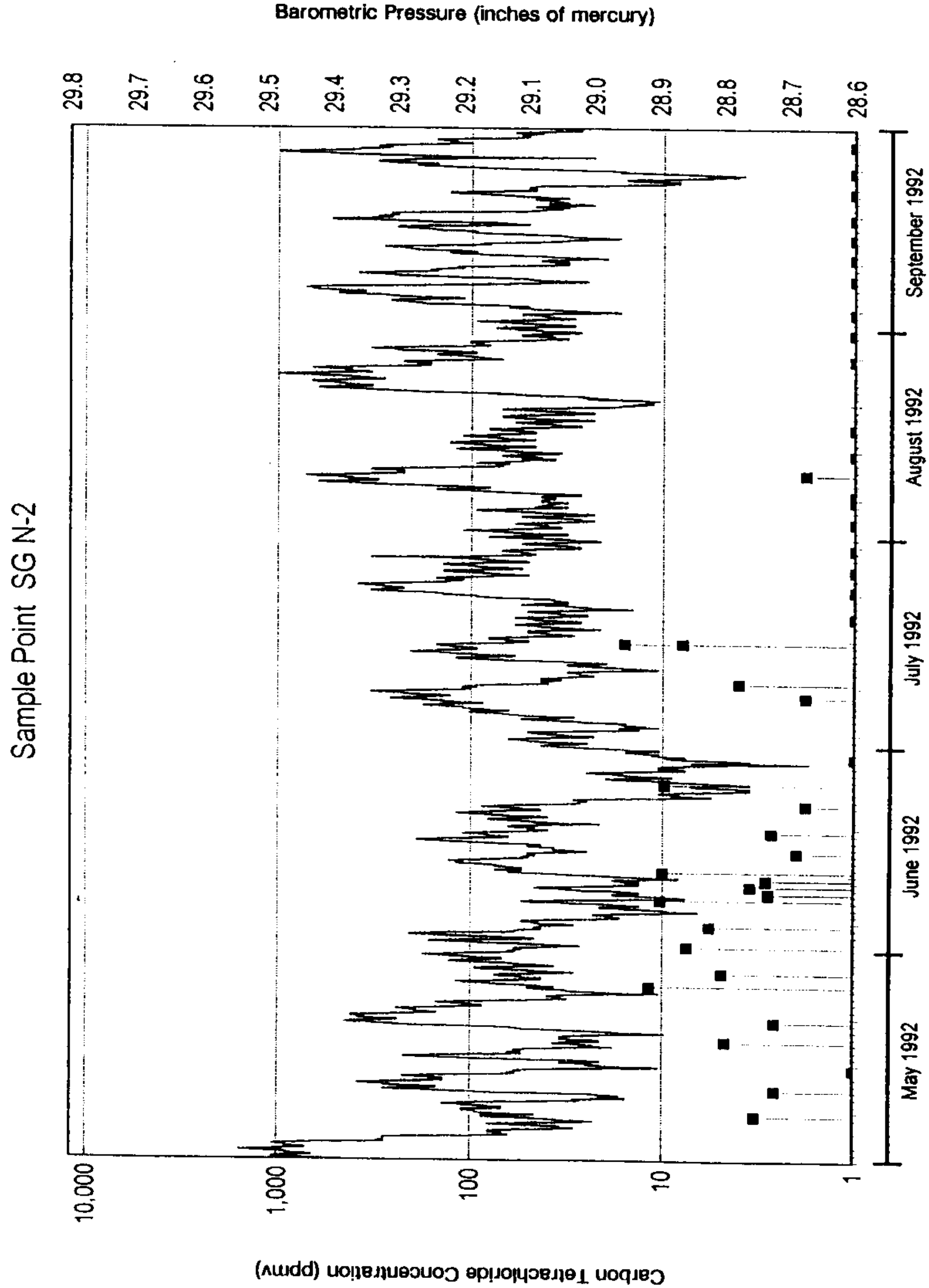


Figure 3. Sample Point SG N-3 Barometric Pressure December 1991 to April 1992 (inches of mercury).

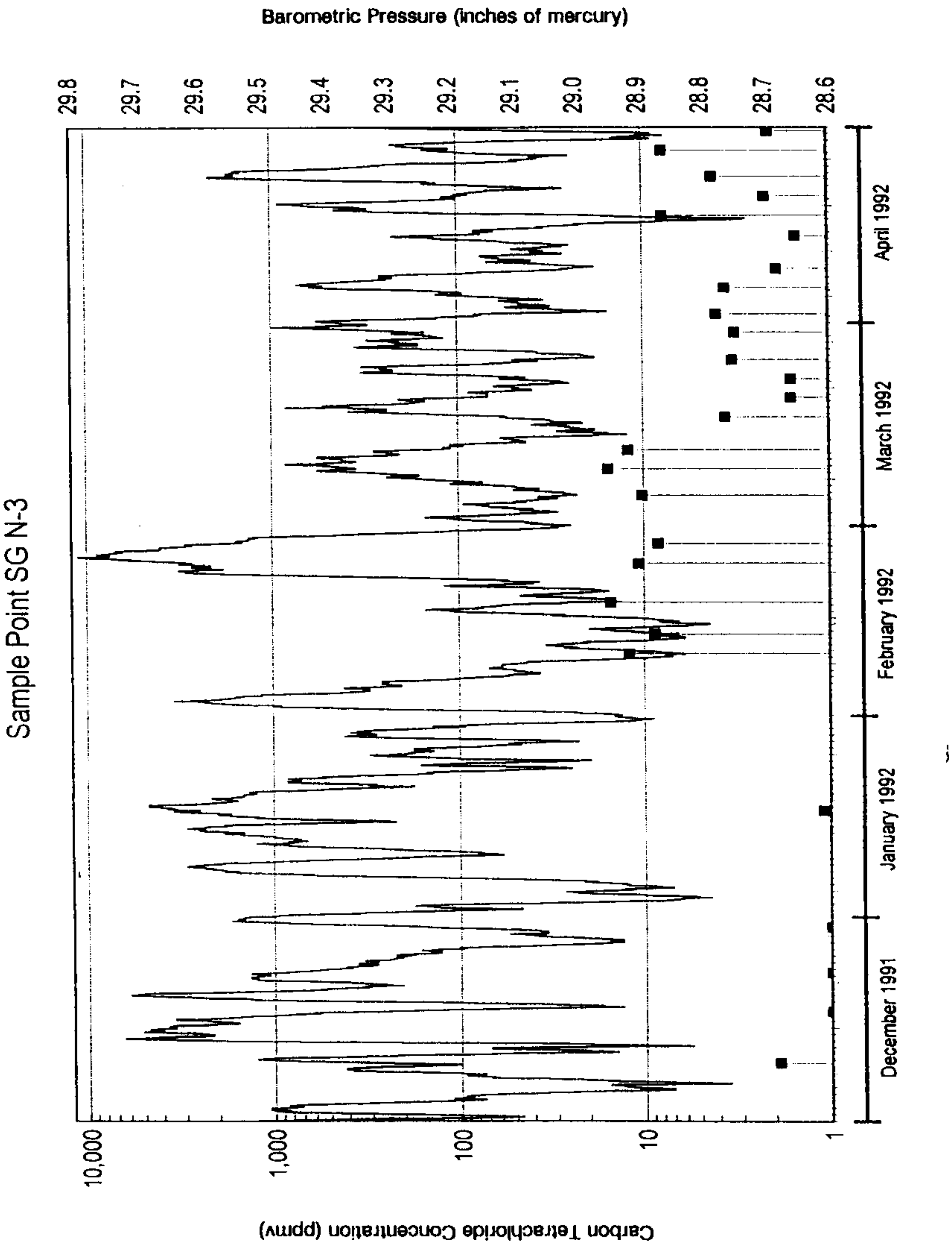


Figure 4. Sample Point SG N-3 Barometric Pressure
May to September 1992 (inches of mercury).

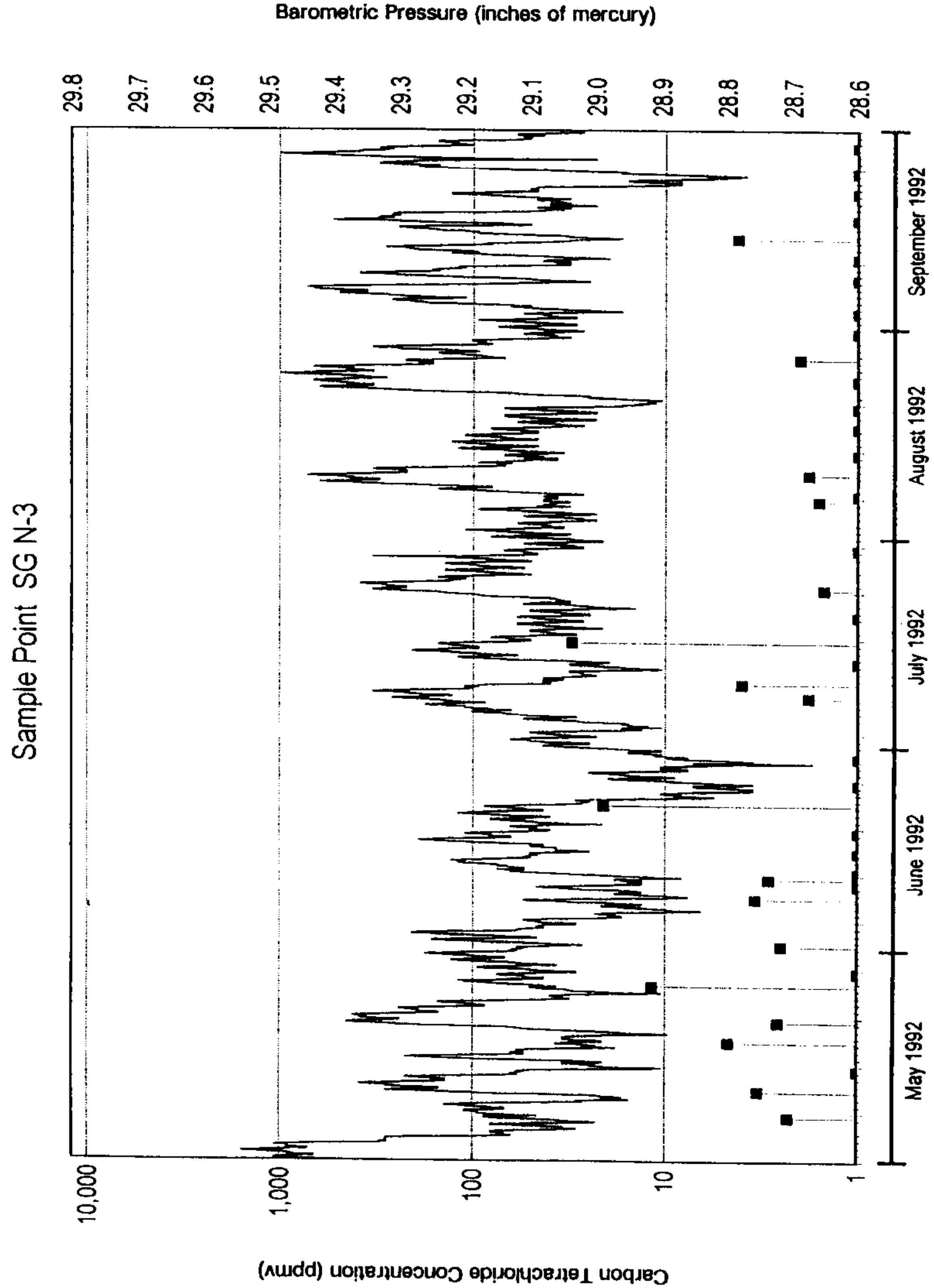


Figure 5. Sample Point SG N-5 Daily Precipitation
May to September 1992 (hundredths of an inch).

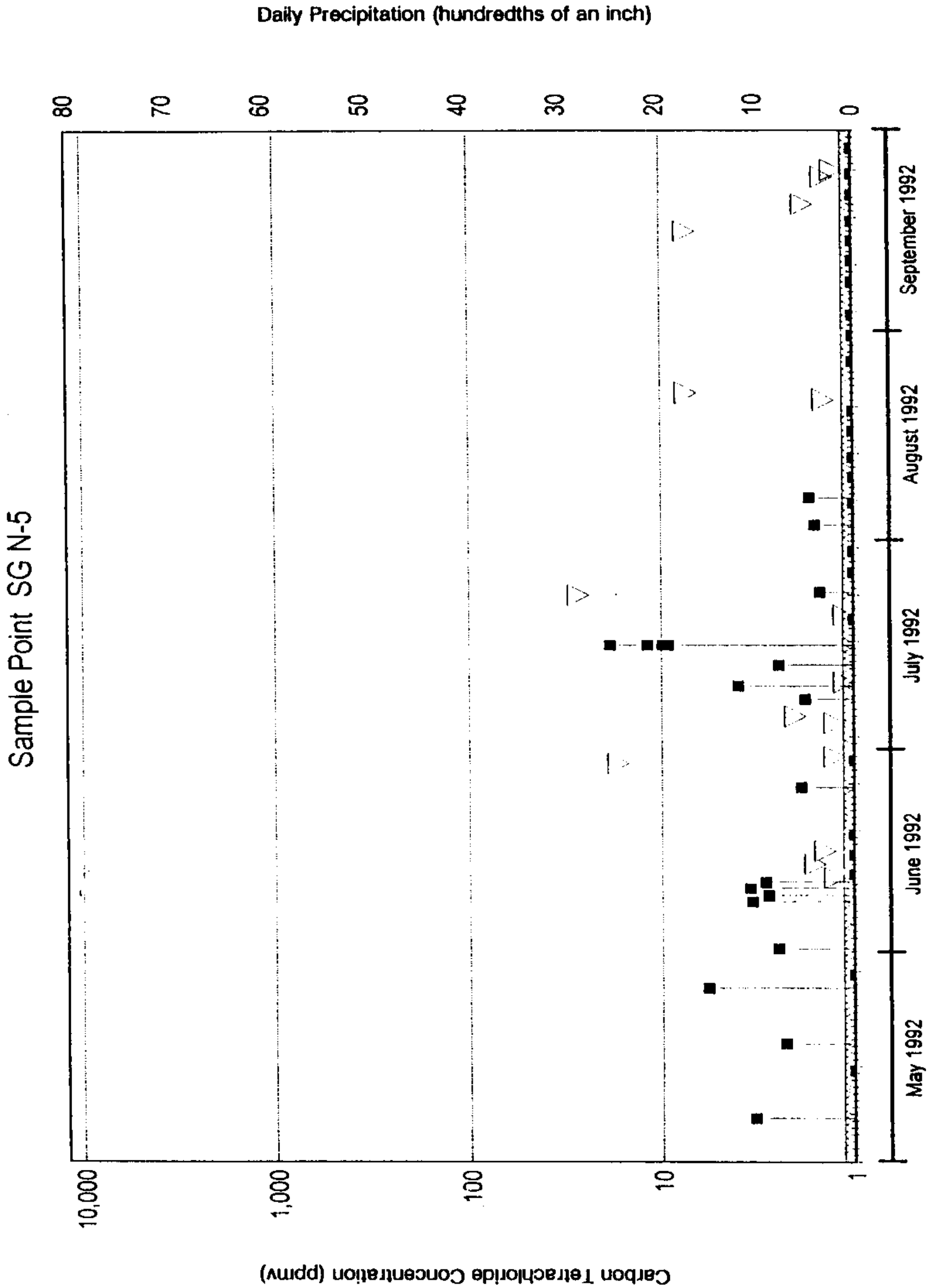


Figure 6. Sample Point SG N-5 Vapor Extraction System Operation Periods May to September 1992.

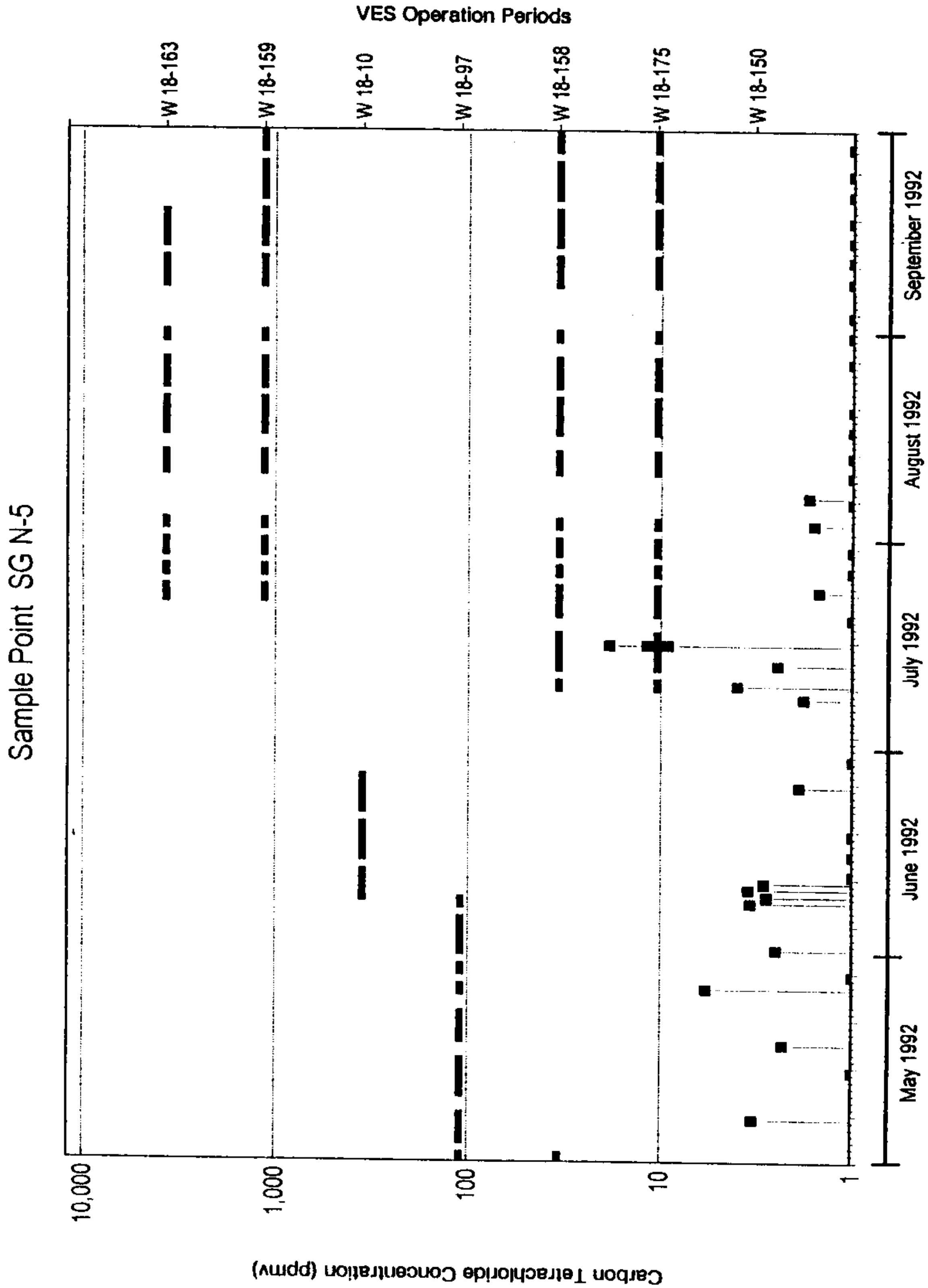
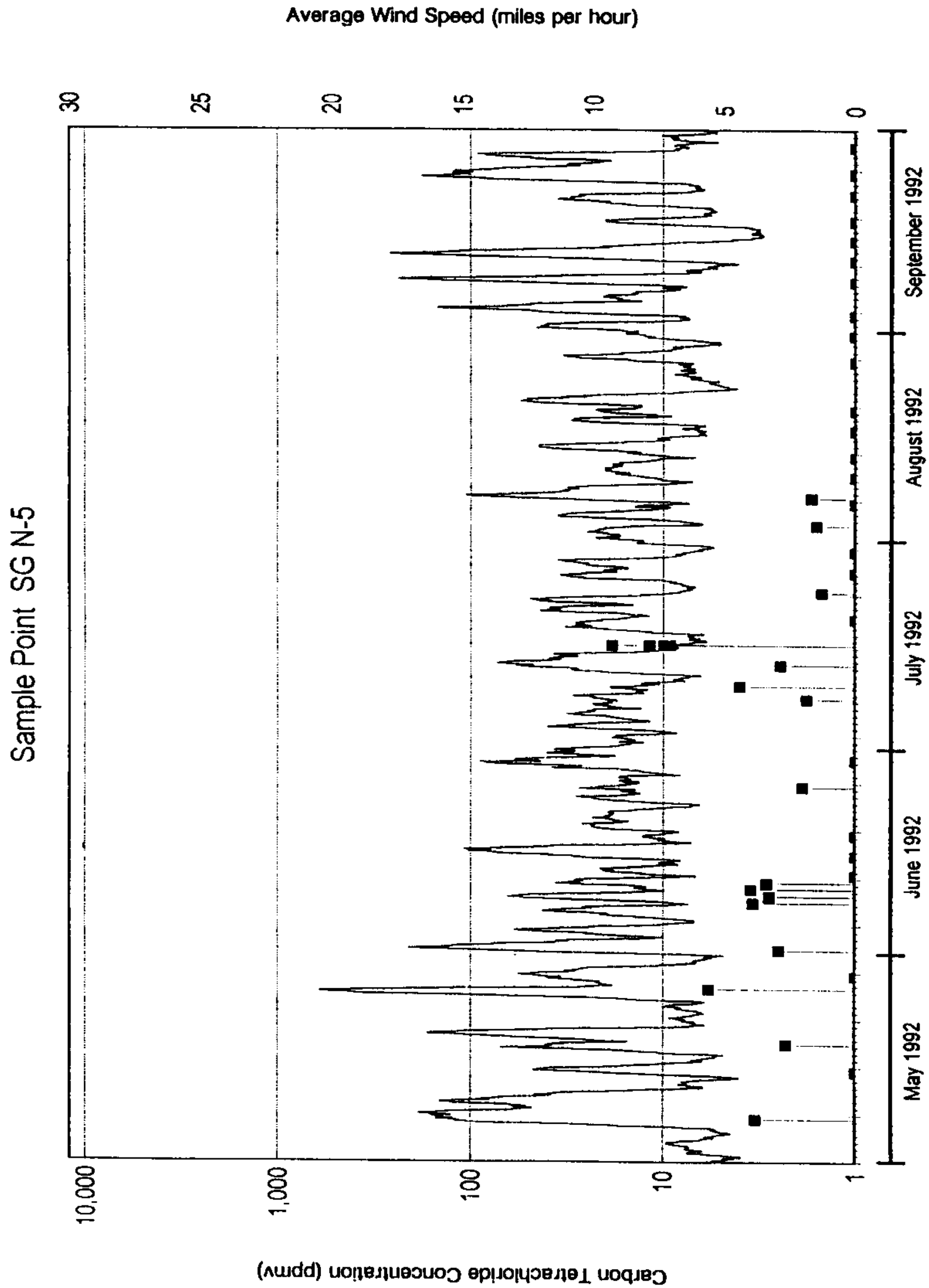


Figure 7. Sample Point SG N-5 Average Wind Speed
May to September 1992 (miles per hour).



9 1 1 2 9 3 1 1 0 5 1

Figure 8. Sample Point SG N-5 Temperature
May to September 1992 (degrees Fahrenheit).

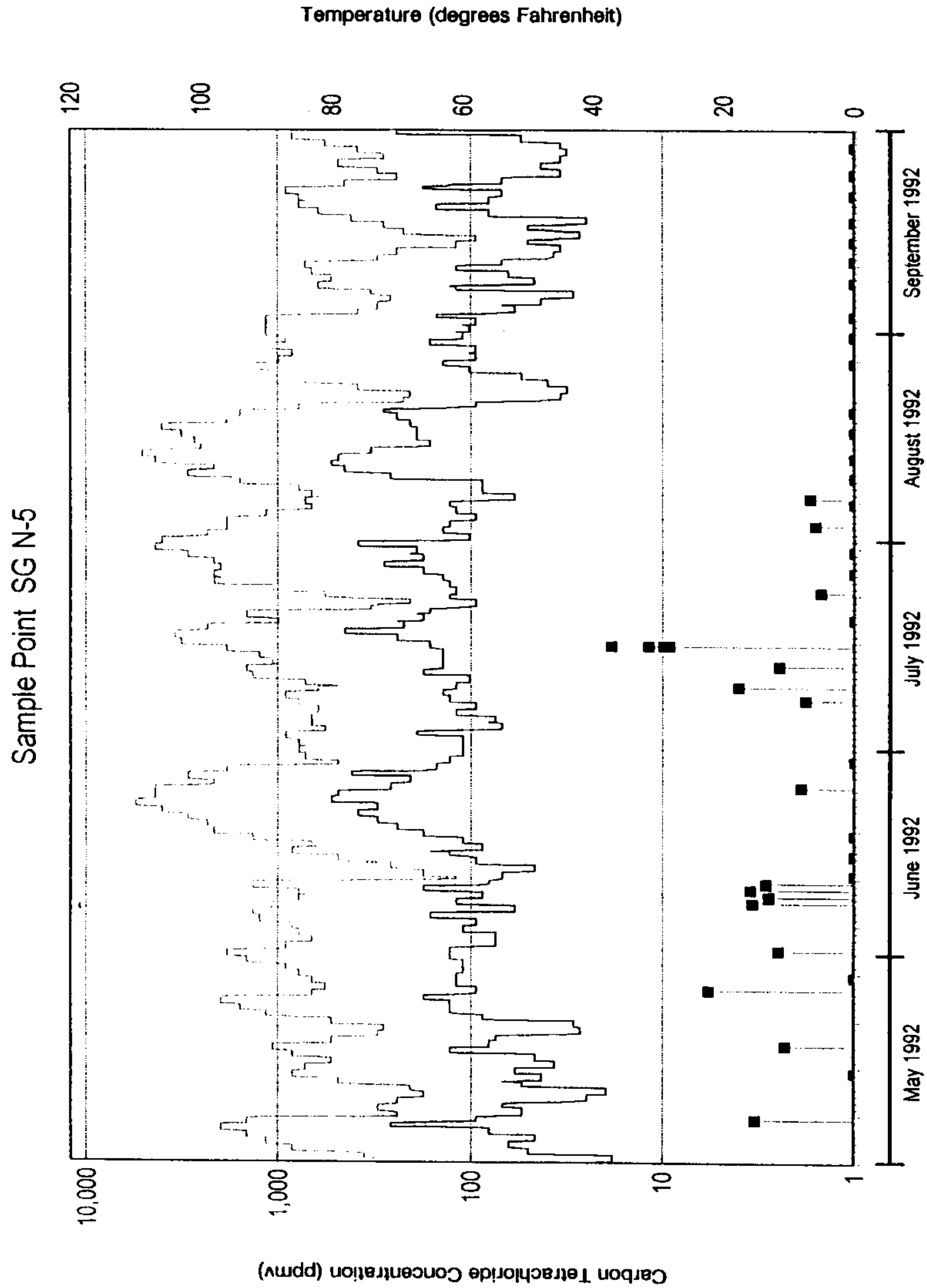


Figure 9. Sample Point SG N-5 Daily Precipitation December 1991 to April 1992 (hundredths of an inch).

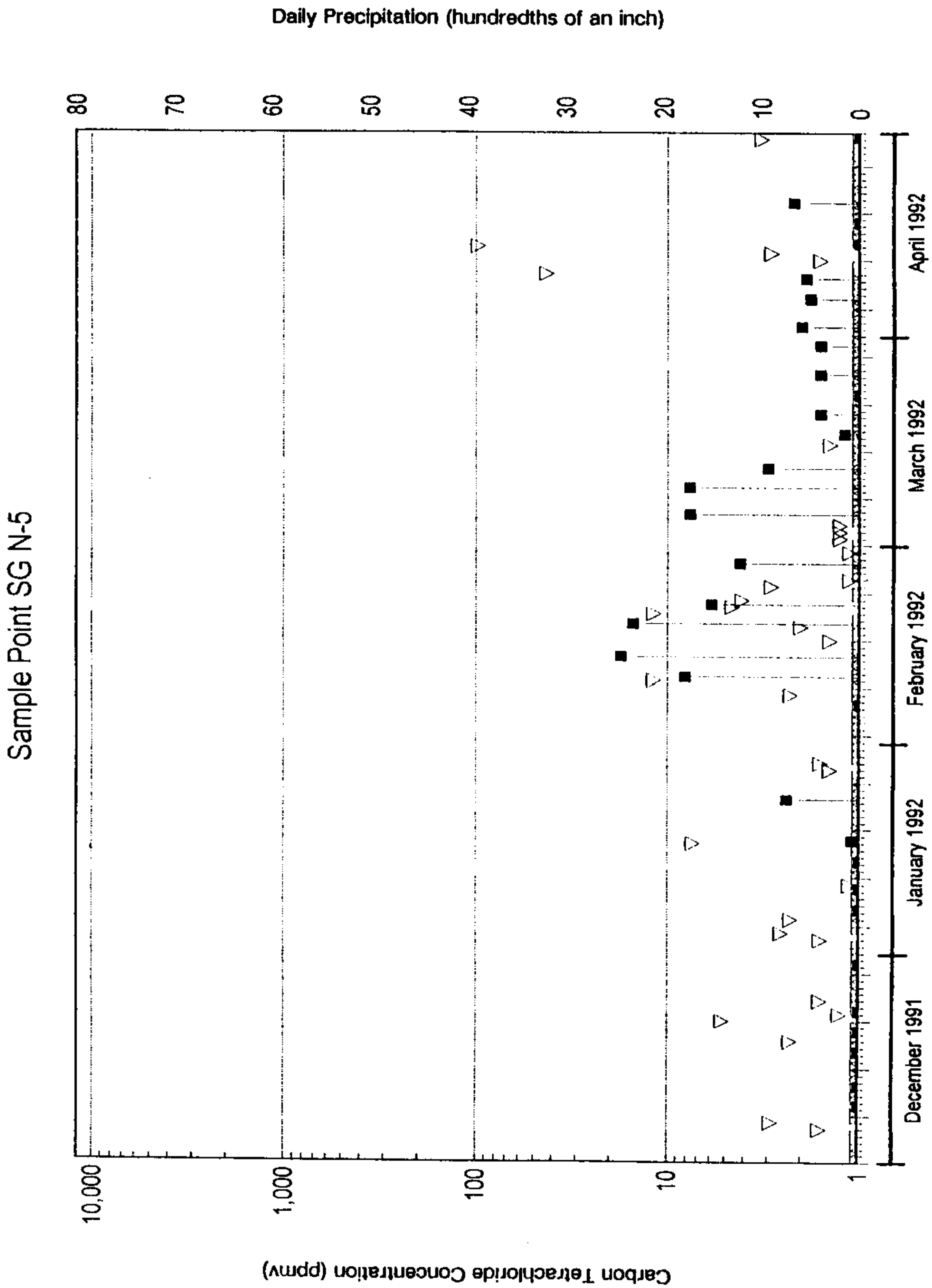


Figure 10. Sample Point SG N-5 Average Wind Speed December 1991 to April 1992 (miles per hour).

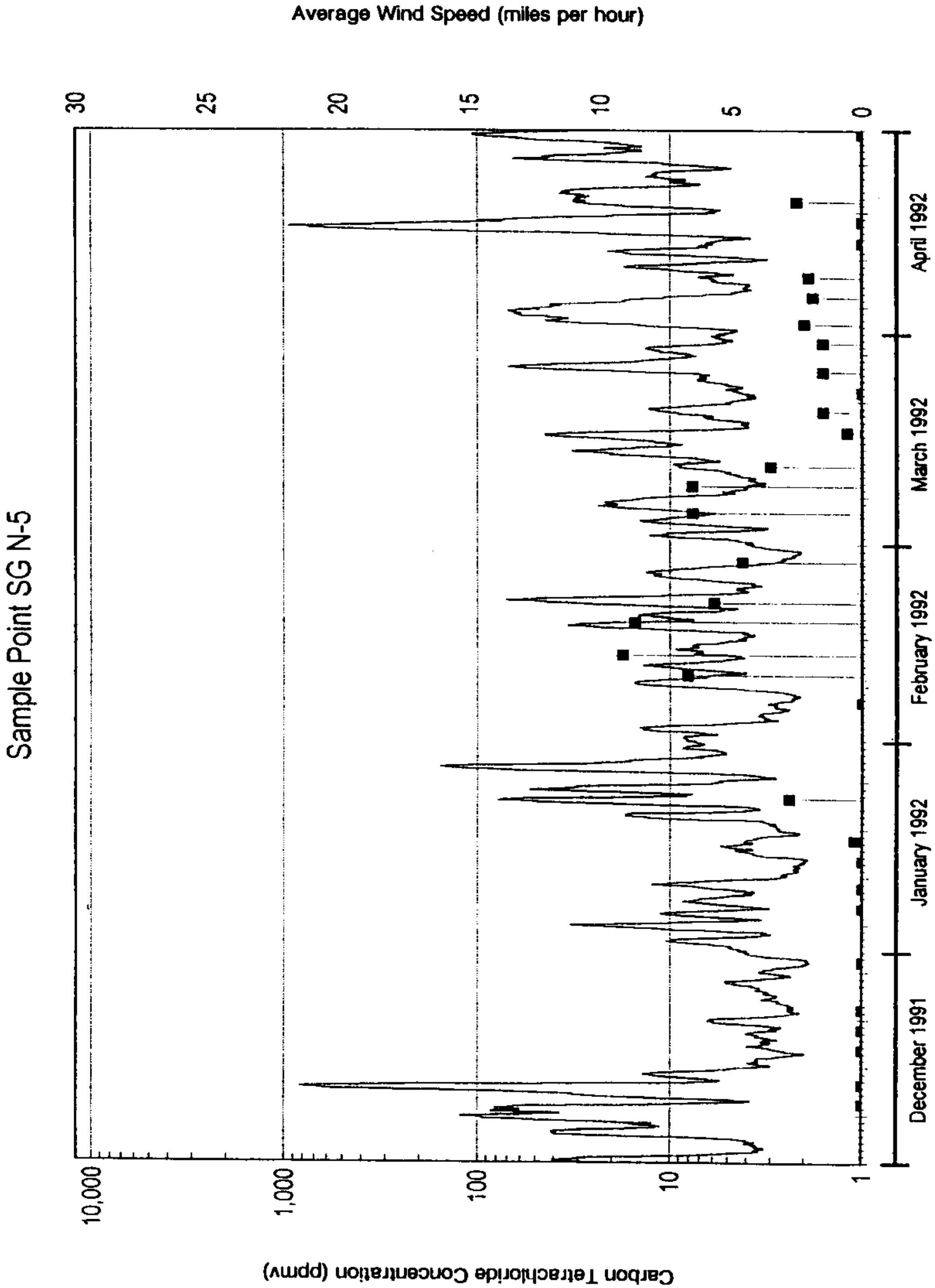


Figure 11. Sample Point SG N-5 Temperature
December 1991 to April 1992 (degrees Fahrenheit).

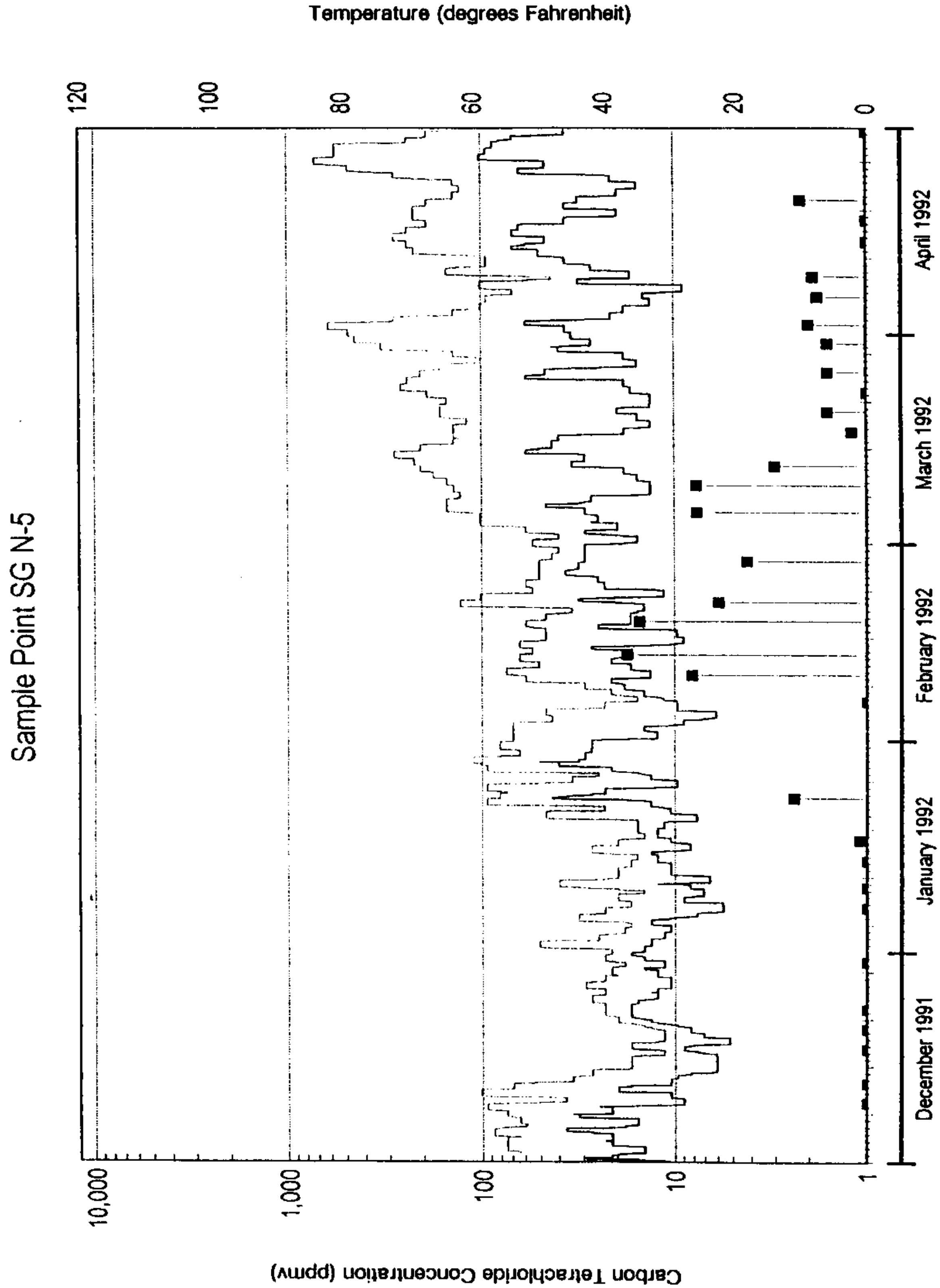


Figure 12. Sample Point W 18-6 Barometric Pressure
May to September 1992 (inches of mercury).

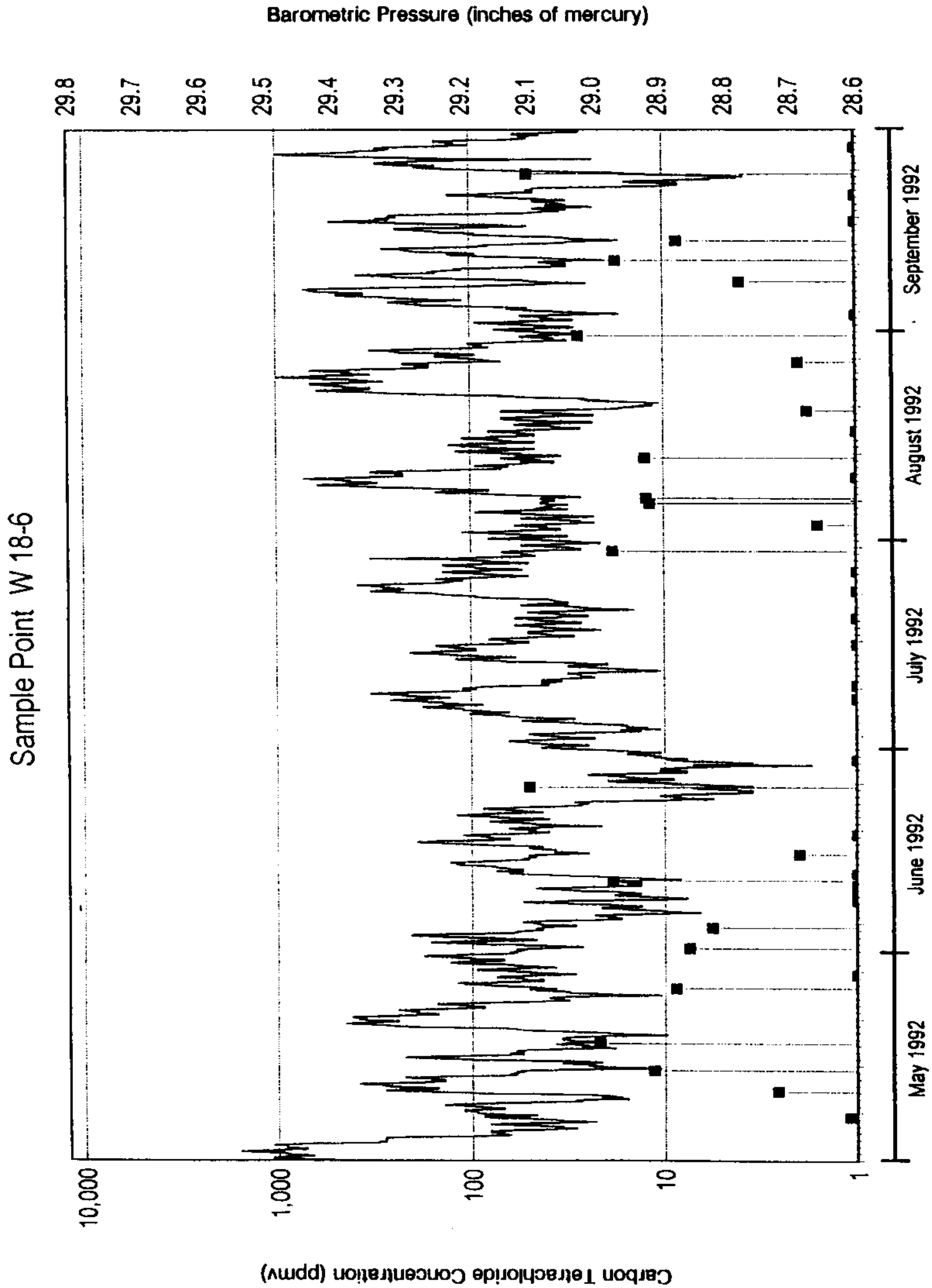
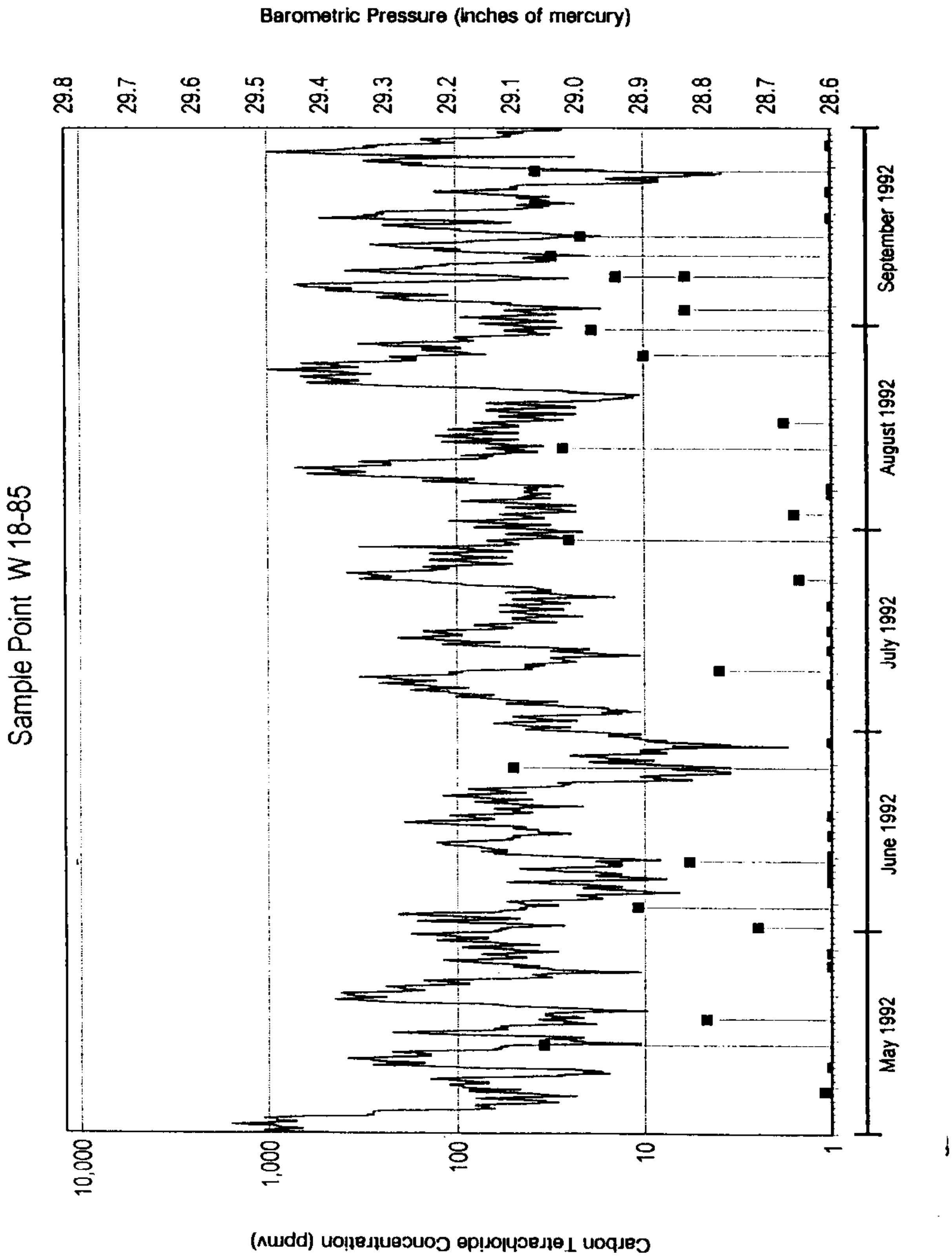


Figure 13. Sample Point W 18-85 Barometric Pressure May to September 1992 (inches of mercury).



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